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AIRPORT STANDARDS

by John Kyle

AIR TRANSPORT DIVISION

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## AIRPORT STANDARDS

John Kyle

All of us who have worked in the field of air transportation will conclude that, at least insofar as volume or traffic is concerned, the industry has come of age. For instance in the twelve months ending April, 1952, 10,567,214,000 passenger miles were chalked up in domestic air travel as compared with 9,859,000,000 for Pullman rail travel. Simultaneously 698,028 passengers were carried across the Atlantic by planes while only slightly more, 783,614, were carried by ships for the same period. This year, with tourist air travel rates in effect, the volume of overseas air travel is estimated to increase by 21 per cent. Therefore, if we consider service to the public as a measure of maturity, air transportation is no longer an infant industry. Why then, with regard to technology, do we baby this transport medium? The industry's leaders keep talking in terms which lead one to suspect that they are not cognizant of the economics of furnishing ground facilities to land and take-off transport ships used in air commerce. I specifically except the airport requirements for military craft, in view of the fact that theirs is an entirely different problem and requires radically different solutions.

To illustrate my point, I should like to discuss two aspects of airfield design which, in my opinion, are being handled in a manner which do not always do credit to the engineering profession.

Airfields generally throughout the country have evolved from small landing areas to major air terminals. In each community, the engineers, with the help of such agencies as the C.A.A. and a large crystal ball, have tried to anticipate future runway requirements. Most large cities have an airport capable of receiving, with a fair margin of safety, ships up to the DC-6 or the Connie. This means, for continental airports, a minimum 6,000 foot runway with a load capacity of around 50,000 pounds per dual wheel assembly. Some of the newer fields have expansion possibilities up to 8,000 feet, the only penalty for such expansion being a greatly increased financial burden on the owner or operator of the airport.

In Los Angeles in 1951, a conference was held to discuss the need for lengthening the runways for future use. An immediate decision was needed because of the necessity for making provision for a highway underpass at the end of one of the major runways. Engineers working in the field of airport design were astonished to hear representatives from four manufacturers, supposedly speaking for the aircraft industry, state that, in their opinion, provisions would have to be made for runways from 12,000 to 15,000 feet long. They further stated that such runways would be required for planes presently on the drawing boards. This plane development had evidently been proceeding without any advice or concurrence from airport operators, who, in the last analysis, would be the ones saddled with the burden of supporting such stupendous runways. In my opinion, there is only the remotest possibility that airport owners or operators could possibly afford the construction and maintenance of such runways and, in any case, because of terrain conditions or available real estate, such runways could not be constructed at the

sites of 90 per cent of the existing fields in the United States.

In contrast to this attitude is the cooperative effort which went into the development of the Avro Jet-I iner which was developed to successfully land and take off from existing fields without damage to existing pavements either from imposed load or angle of incidence of Jet to runway surface.

It must be remembered that the length of a runway needed for plane take-off or landing is only a function of the design of the plane and can be corrected, within a fairly wide range, by adequate design of the plane motive power characteristics, braking devices and landing gear.

This is not an isolated problem of Los Angeles, Chicago or New York, but rather a problem common to all major air centers in the United States - yes, even throughout the world.

Many of the fields to which I refer have been expanded to meet the requirements of Technical Standard Order No. N6a issued by C.A.A., or its counterpart ICAO. This technical order up to now has been the Bible in the design of landing areas. It specified 5900 foot runways for continental fields and up to 8400 foot for International fields.

It is suggested that the civil engineering profession involved in airport design take a firm stand so that the requirements laid down by Technical Standard Order No. N6a shall be considered as the ultimate to which airports will be constructed and that the plane designers be advised that this is the maximum they can anticipate in runway construction. With this restriction in mind, they can so design aircraft that they can operate safely on the airports of the world. This would necessitate modifications being built into the ships rather than into the runways. When one considers that over 2 and 1/3 billion have already been invested in landing fields, the magnitude of any change in this category can be readily appreciated.

Another aspect of the problem seems to have been completely overlooked. We take as a matter of course the great changes in landing techniques that have occurred because of the use of landing flaps and reversible propellers, both of which have changed landing distances. With rotary wing aircraft and converter planes well beyond the blueprint stage, is it not conceivable that we are in for still more startling changes in runway lengths and requirements? Should this come to pass, huge investments in inordinately long runways would be rendered useless and, in fact, would become a liability, requiring as they do constant maintenance, policing and rehabilitation.

I come now to the second engineering problem requiring the coordinated efforts of our profession. That item is pavement strength.

The railroads went through similar growing pains in their development and, it seems to me, have worked out a valid formula with regards to relation of motive power to design and construction of the right-of-way.

Let us look briefly at the development of the locomotive as we knew it in the United States from 1829 to the present. Graphically, if we plot weight of locomotive against year each engine was first developed, we get the following graphic illustrations (See Fig. 1).

Obviously, no stagnation of development was shown here, but we all know that even the newest engines fall within the allowable stresses on existing bridges, trestles and embankments. How was this done? By the cooperative effort within the industry under which the civil engineer and the mechanical engineer, working side by side, adopted standards and held to these standards as to clearances and axle loading. The latter standard is, of course, well known to all designers and is reflected in the Cooper loadings.

With the purse strings held by one group on both the purchase of engines and the construction of the railroads, it was a simple matter to see that there

was thorough cooperation within the two groups of engineers. Such is not the case in aircraft operation. Usually the landlord at an airport is not an aircraft operator and, in any case, all major airports are used by a multiplicity of operators, both scheduled and non-scheduled.

The economic necessity of cooperation by the airport designers and the aircraft designers is not as easily brought into focus as it is in the railroad industry, but I see no reason why the economic facts of life cannot be as readily explained to a group of technicians in the aircraft industry as they have been demonstrated within the railroad industry.

In paralleling the locomotive design problem, I have here the weights of the largest of the new commercial aircraft brought out in the years 1920 - 1950. (See Fig. 2)

You will note the pattern is similar to that of the locomotive. However, the pattern of a standard design criteria has been lacking. In the development of a long term lease between the Port of New York Authority and the various airlines it has been necessary to investigate the various runway design formulae to determine which would be applicable over a long period of time for deciding which of the new planes would be able to land on the fields we operate without damage to the pavements. Our investigations led us to the conclusion that the best formulae evolved to date was the one discussed in the 1949 Spring meeting of the ASCE and published in the May, 1950, Proceedings of the ASCE. As a basis for discussion, I propose that the industry accept the use of Influence Charts and the accompanying Westergaard design formula as its counterpart of the Cooper loadings. This formula, as you know, is predicated upon the use of an influence Chart on which are plotted the loadings of the various supporting gears of an aircraft. Should we adopt for each airport as criteria of design a specified pavement thickness and subgrade modulus and match this to a standard aircraft design, it then becomes a simple arithmetic calculation to determine if another given plane, while it is still in its design stages, will be acceptable on a given airport. (See Fig. 3)

In the event that in this early stage, the plans appear unacceptable, modifications can be made at this point without undue hardship on either the manufacturer or the potential user of the plane. If, in spite of advice that a plane will be destructive to the country's airports, the manufacturer still persists in a poorly engineered design, I would propose that the airport operators decline to allow planes of this design to use the fields.

Fortunately for the engineers, an organization for the coordination of the work of airport operators has been established. It is known as the Airport Operators Council and numbers among its members operators of all the major air terminals in the country. The technical staffs of the member organizations of the Council might well serve as a nucleus for the implementing of this technique.

One other factor of aircraft design, although it does not impinge directly upon the design of the airport, should, in my opinion, receive prompt comprehensive engineering study. This is the factor of noise which presently, because of its close association in the public's mind with aircraft accidents, has of late been receiving much public attention. Prominent engineers have stated that it is not possible to disassociate airplane noise from more efficient aircraft operation, particularly in the field of jet planes. Although this conclusion may be correct from an aeronautical point of view, I doubt whether the people living near airports will be satisfied with so academic an approach to the problem. Most of us remember the very fine mechanical performance of the steam automobile. It departed from the scene not because of the tech-

nological superiority of the gasoline buggy but because it had certain inherent characteristics which were unacceptable to the public. So, I am afraid that, should the plane designers insist on making their products in such a manner that the noise levels produced, seriously affect those living in the vicinity of airports and air routes, there would be such a public outcry that such aircraft would be banished from the skies or at least from all areas adjacent to large cities.

The Port of New York Authority is presently sponsoring a study to determine the characteristics and noise levels caused by ground run-up of aircraft in areas adjacent to its airports. Upon completion of this study, an attempt will be made to develop noise baffling devices for use in the vicinity of warm-up, hangar and test areas.

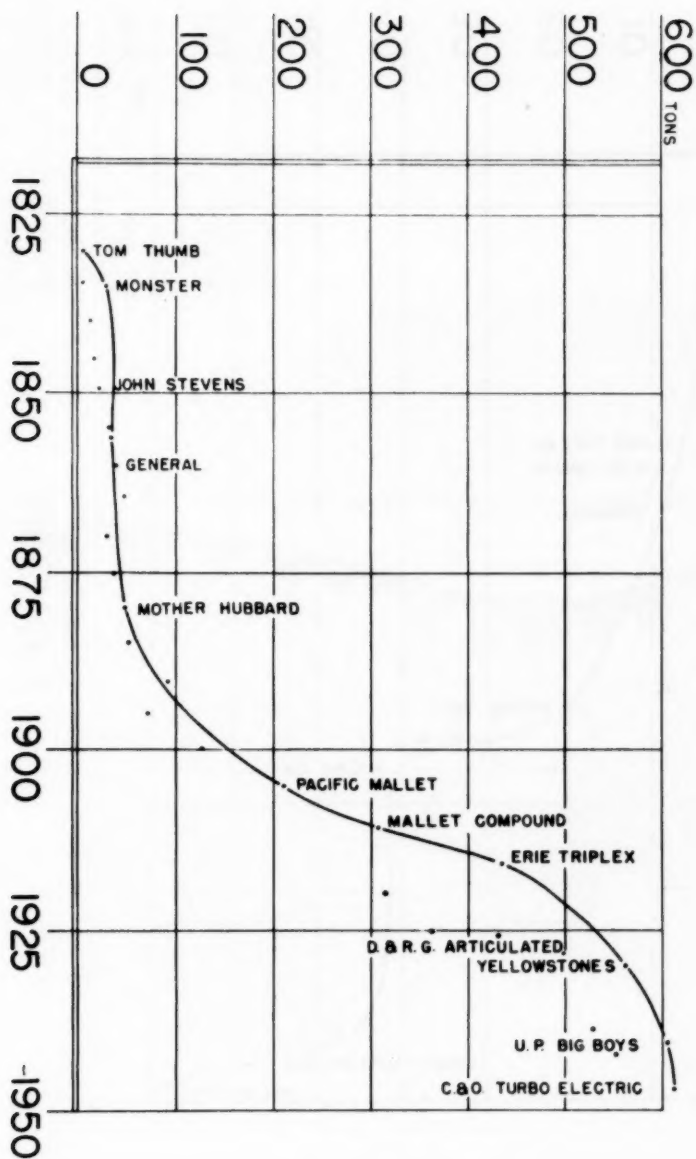
In conclusion, it is suggested that an organization such as the American Society of Civil Engineers act as sponsor for a proposal to examine realistically the inter-relationship of aircraft design with design of airport facilities, particularly with regard to the runways needed for the ground movement and take-off of such aircraft. Goals to be achieved would be the following:

1. Limiting of runway lengths to a fixed criteria. Suggested criteria to be in accordance with Technical Standard Order No. N6z in its present form.
2. Limiting weight of aircraft and configuration of aircraft landing gear to a design which will impose no greater unit tensile stress, in accordance with the Westergaard formula, than 485 p.s.i.
3. Pioneer work on noise baffling devices for use at airports and on airplanes.

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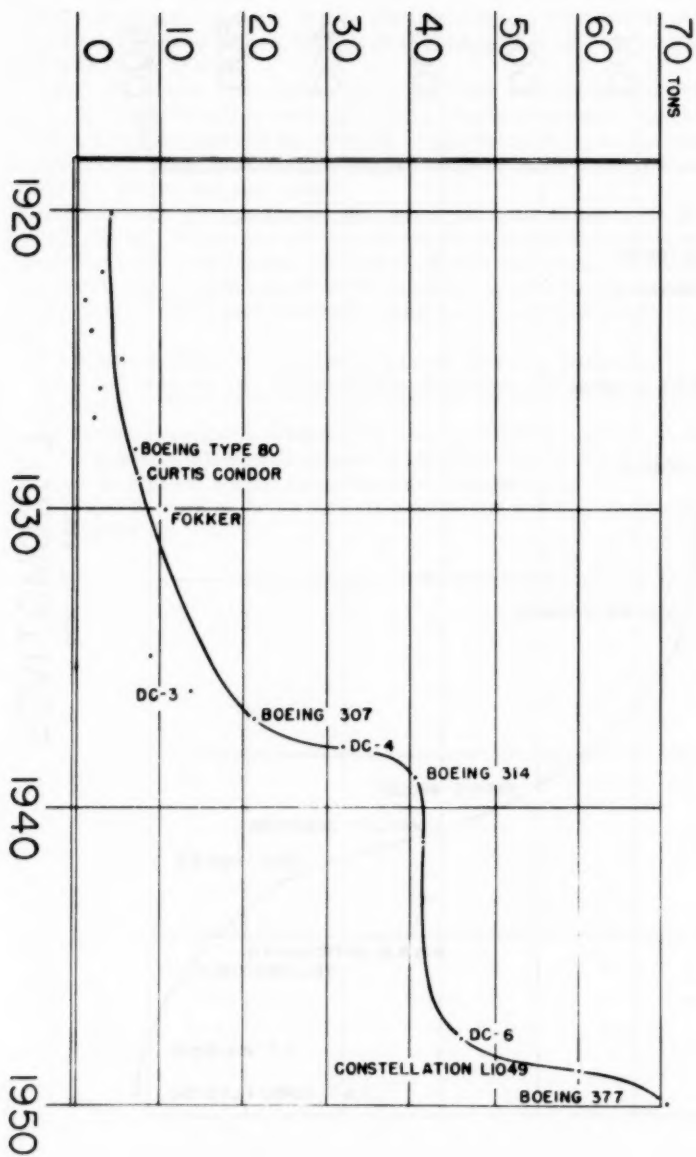
# LOCOMOTIVES

1825 TO 1950

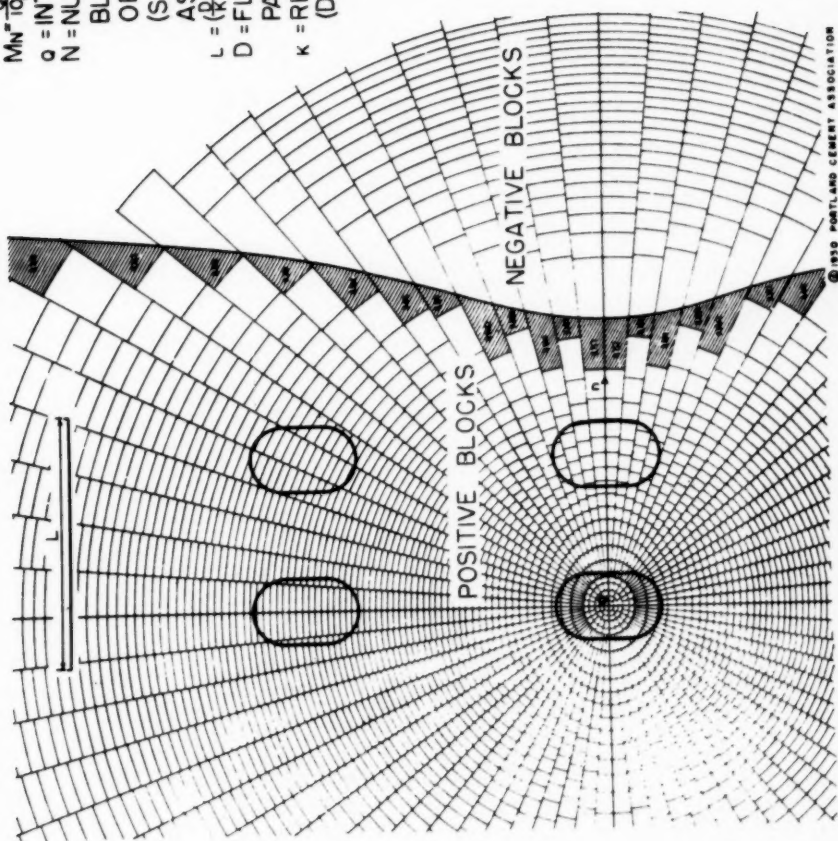


# AIRCRAFT

1920 TO 1950



$MN = \frac{qL^2 N}{10,000}$   
 $q$  = INTENSITY OF LOADING  
 $N$  = NUMBER OF POSITIVE  
 BLOCKS MINUS NUMBER  
 OF NEGATIVE BLOCKS  
 (SHADED BLOCKS COUNT  
 AS ONLY FRACTIONS)  
 $L = \left(\frac{D}{k}\right)^{1/4}$   
 $D$  = FLEXURAL RIGIDITY OF  
 PAVEMENT  
 $k$  = RIGIDITY OF SUBGRADE  
 (DENSITY OF LIQUID)



INFLUENCE CHART FOR THE MOVEMENT  $M_N$  IN A CONCRETE PAVEMENT  
 DUE TO A LOAD IN THE INTERIOR OF THE SLAB  
 (SUBGRADE ASSUMED TO BE A DENSE LIQUID POISSON'S RATIO FOR PAVEMENT ASSUMED TO BE 0.15)

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